

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<p>(51) International Patent Classification ⁴ : A61F 2/70, B25J 15/00</p>	<p>A1</p>	<p>(11) International Publication Number: WO 85/ 04796 (43) International Publication Date: 7 November 1985 (07.11.85)</p>
<p>(21) International Application Number: PCT/SE85/00182 (22) International Filing Date: 18 April 1985 (18.04.85) (31) Priority Application Number: 8402223-5 (32) Priority Date: 19 April 1984 (19.04.84) (33) Priority Country: SE</p> <p>(71) Applicant (for all designated States except US): S. H. SVENSK HANDIKAPTEKNIK AB [SE/SE]; Box 7112, S-103 87 Stockholm (SE).</p> <p>(72) Inventors; and (75) Inventors/Applicants (for US only) : HOLMQVIST, Torbjörn [SE/SE]; Kolmårdsvägen 53, S-181 64 Lidin- gö (SE). PERSSON, Ulf [SE/SE]; Klövervägen 4, S- 145 67 Norsborg (SE).</p> <p>(74) Agents: WENNBORG, Göte et al.; Kransell & Wenn- borg AB, Sandhamnsgatan 42, S-115 28 Stockholm (SE).</p>		<p>(81) Designated States: AT (European patent), AU, BE (Eu- ropean patent), BR, CH (European patent), DE (Eu- ropean patent), FR (European patent), GB (Euro- pean patent), IT (European patent), JP, LU (Euro- pean patent), NL (European patent), NO, SE (Euro- pean patent), US.</p> <p>Published <i>With international search report.</i></p>
<p>(54) Title: A METHOD AND A DRIVE ASSEMBLY FOR OPERATING AND LOCKING COMPONENT MEM- BERS OF ELECTRICALLY OPERATED PROSTHESES, MANIPULATORS AND LIKE DEVICES</p>		
<p>(57) Abstract</p> <p>A drive unit for electrically driven pros- theses, manipulators and the like, for example, the gripping members of an artificial arm or industrial robot, comprises an electrical drive motor (2) hav- ing an output shaft which drives an active compo- nent, for example a gripping means, via a trans- mission arrangement (4). The output shaft (7a) of a brake-motor (7) has arranged thereon a sleeve pro- vided with a part having a right-hand screw thread and a part having a left-hand screw thread in en- gagement with brake means such as shoes (8, 9) which upon activation of the brake-motor engage a brake disk (6a) connected to the output shaft (2a) of the drive motor. The brake-motor is activated upon completion of the movement of the drive motor and therewith locks the active component in the position to which it has been moved without the occurrence of play.</p>		

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	GA	Gabon	MR	Mauritania
AU	Australia	GB	United Kingdom	MW	Malawi
BB	Barbados	HU	Hungary	NL	Netherlands
BE	Belgium	IT	Italy	NO	Norway
BG	Bulgaria	JP	Japan	RO	Romania
BR	Brazil	KP	Democratic People's Republic of Korea	SD	Sudan
CF	Central African Republic	KR	Republic of Korea	SE	Sweden
CG	Congo	LI	Liechtenstein	SN	Senegal
CH	Switzerland	LK	Sri Lanka	SU	Soviet Union
CM	Cameroon	LU	Luxembourg	TD	Chad
DE	Germany, Federal Republic of	MC	Monaco	TG	Togo
DK	Denmark	MG	Madagascar	US	United States of America
FI	Finland	ML	Mali		
FR	France				

A method and a drive assembly for operating and locking component members of electrically operated prostheses, manipulators and like devices

5

Field of Invention

The present invention relates to a method of operating and locking component members of electrically operated prostheses, manipulators and like devices, such as the gripping elements of artificial arms and robots in which there is used a drive motor from which movement is transferred to said component member via transmission means for the purpose of effecting movement of said member.

15 The invention also relates to a drive assembly for use when carrying out the method.

Prostheses are often operated with the aid of so-called myo-signals, which involve the placing of electrodes in the region of the muscles to be used in effecting a given movement of the prosthesis. Upon activation of the muscle there is generated an electric signal which is captured by the electrode and utilised to activate the prosthesis drive unit.

20 Various types of active components in orthosis/prosthesis for upper and lower extremities are controlled with the aid of myo-signals. Hand hook and elbow constitute examples of such active components.

The invention can also be applied, however, to various kinds of manipulators and like devices, for example robotic gripping means, with which control signals other than myo-signals are used.

Background Art

Various kinds of prostheses drive systems are known to the art. For example, there is described in



Austrian Patent Specification No. 338,410 (Viennatone)
a gear mechanism for an orthosis, prosthesis or like
device in which drive movement is effected with the
aid of a left-hand and a right-hand thread. DE-A-24 26 787
5 (Forschungsinstitut für Orthopädie-Technik) describes a
safety device for an artificial hand with which there is
used a separate latching means for holding the fingers
of the prosthesis in their closed position.

One serious disadvantage with previously known
10 prostheses of this and similar kinds in which a drive
motor is controlled to produce movement in the artificial
component is that it is not possible to obtain distinct
positioning of the active component. The cause hereof is
related to the intrinsic inertia of the system, which
15 prevents the component from being stopped in precisely
the correct position. A further, related disadvantage is
that it is not possible to eliminate play in the known
prosthesis. Neither is it possible as a rule to readily
prize or force a prosthesis which has inadvertently
20 locked, this possibility being of extreme importance with
most types of prostheses. As will be understood when a
prosthesis locks in a certain position and cannot be
readily prized free, the attempts made to force the
prosthesis may result in serious damage and injury.
25 Another disadvantage encountered with the majority
of hitherto known prostheses is that in order to function
satisfactorily they must be manufactured to extremely
accurate tolerances.

30 Object of the Invention

Accordingly one object of the invention is to
provide a method of the aforesaid kind which avoids the
aforementioned disadvantages encountered with known
drive systems and which enables the active elements of
35 the prosthesis to be positioned accurately without losing,
for example, the gripping power of such elements as a

result of play in the prosthesis or the like.

A further object is to provide a drive system of the aforesaid kind which enables the active component to be readily prized free or forced even when in a
5 locked position.

Another, important object is to provide a drive system for prostheses, manipulators and like devices which can be controlled electronically in a simple and reliable fashion and which can thereby be adapted more
10 readily to the varying requirements demanded in certain contexts, for example, to different patient categories and the environment in which a robot is to work.

A further object is to provide an operationally reliable drive and control system which can be manufactured
15 without requiring accurate manufacturing tolerances in respect of the different components of the device.

Brief Disclosure of the Invention

These and other objects are fulfilled by a method
20 according to the invention which in its widest aspects is characterized by in addition to the drive motor also using a brake-motor and activating said brake-motor during the final stage of movement for locking said component member in the position to which it has been
25 moved, or subsequent to the completion of said movement.

The use in accordance with the invention of a separate brake-motor which produces precise locking of the active component in an adopted position enables the active component to be positioned or oriented in a
30 distinct and play-free fashion. The brake-motor also enables the active component member to be forced free when so required. The separate electric motors for effecting the respective driving and locking movements means that the arrangement as a whole can be given a
35 simple and robust form, which in turn results in a reliable function without requiring manufacturing

tolerances.

Normally the drive movement is obtained through a series-motor, and consequently the applied current will increase when movement of the active component meets with resistance, for example, when said component grips an object. In a preferred embodiment of the invention this fact is utilised to guide the brake-motor, by arranging for said motor to be activated when the strength of the current supplied to the drive motor exceeds a given value.

Alternatively, a brake-motor start signal can be transmitted when the movement of the active component ceases or begins to cease, for example, when gripping an object.

In one particular application of the invention for guiding and controlling prostheses in which myo-signals are used in a known manner to control movement of the drive motor, such myo-signals are also used to control the brake-motor. This affords particular advantages when the brake-motor is to be activated to release the active component from a locked position, i.e. the brake-motor is caused to rotate in a direction opposite to the rotational direction in which the locked state was achieved.

The invention also relates to a drive assembly for operating electrically operated prostheses, manipulators and the like, for example the gripping elements of artificial arms and robots, the drive assembly including an electric drive motor having an output shaft, a transmission means for transmitting movement of the output shaft to a drive shaft associated with an active component member, for example a gripping instrument, said drive unit being characterized by an electrically operated brake-motor having an output shaft which co-acts with brake means arranged to lock the active component in an adopted position by engagement with an element operatively

connected to the drive-motor output shaft, and in that control means are provided for activating the brake-motor in the latter stages of the movement of said active component or subsequent to the completion of said movement.

In the case of an embodiment preferred in practice the brake-motor output shaft carries a sleeve having a part provided with a right-hand screw thread in self-braking engagement with one brake means such as a shoe, and a part provided with a left-hand screw thread in self-braking engagement with another brake means such as a shoe.

This provides a mechanically simple and reliable arrangement capable of rapidly applying powerful braking forces.

The self-braking or irreversible features of the screw threaded sleeve parts means that the braking force will be maintained despite interruption of the drive current to the brake-motor immediately the brake means have been applied, thereby minimising the current consumed by the drive and brake units.

One problem with the described arrangement, however, is that the torque generated by the brake-motor is normally not sufficient to release the brake means such as shoes when reversing the direction of rotation.

This problem is solved, however, with a preferred embodiment of the invention by providing on the brake-motor shaft an eccentric abutment element which when rotating the brake-motor shaft in the opposite direction moves through a dead space corresponding to approximately half of a revolution and then exerts an impact force on an element associated with the aforesaid shaft sleeve. This impact force is sufficient to break the self-braking effect, whereafter the brake means can be moved to their release position without difficulty.

In accordance with another embodiment of the

invention the drive-motor output shaft has arranged concentrically thereon a brake drum having a brake disk against the brake shoes engage. Despite its simplicity in design, a disk brake of this kind is highly effective.

5 Furthermore, the brake drum shaft may partially enclose the drive motor, which in practice means that the two motors, namely the drive motor and the brake-motor, are positioned close to one another, thereby utilising the space available in the best possible manner,
10 this space normally being restricted in a prosthesis of the kind in question. In other words the invention provides a particularly compact drive and brake assembly.

In order to provide for effective control of both drive and brake-motors, the control means may include a
15 sequence part having two or more derivation units for applying and releasing the brake at a desired moment in time, and one or more delay circuits arranged to prevent movement of the drive motor before the brake has been released and to prevent play before the brake has engaged.

20 Derivation units and delay circuits of the aforesaid kind constitute simple and inexpensive electronic components, which can be used to advantage in a drive and brake assembly according to the invention.

In addition to prostheses a drive and brake
25 assembly according to the invention can also be used to advantage in many other contexts, for example, with various types of manipulator, such as robots and like devices. In this case the control signals used to activate the two motors are normally produced from a different
30 source, insomuch as myo-signals are not used to control said motors.

The invention will now be described in more detail with reference to an embodiment thereof illustrated in the accompanying drawings.

Brief description of the Drawings

Figure 1 is a cross-sectional view of a drive assembly or unit according to the invention for use in conjunction, for example, with an artificial arm or
5 hand.

Figure 2 is a sectional view taken on the line II-II in Figure 1.

Figure 3 is an end view of part of the drive unit illustrated in Figure 2.

10 Figure 4 illustrates schematically an artificial hand having rigid three-point engagement and incorporating a drive unit according to the invention.

Figure 5 is a side view of the artificial hand illustrated in Figure 4.

15 Figure 6 is a block schematic illustrating an example of electronic components for a drive unit according to the invention.

Figure 7 is a diagram illustrating examples of control signals used for controlling the drive unit.

20

Description of a Preferred Embodiment

Figures 1-3 illustrate a drive assembly or unit 1 capable of being used, for example, in an electrically operated artificial terminal device such as a hand or a
25 an industrial robot.

The drive unit includes an electric motor 2 having an output shaft 2a. The drive motor may be of a more or less conventional kind and is driven by a six volt battery.

30 The output shaft 2a carries a gear belt drive 2b comprising a belt 3 which extends over a belt wheel 4b on an input shaft 4a of a planet gear box 4. The output shaft 4c carries a gear belt drive 4d incorporating a gear belt 5.

35 Arranged concentrically on the output shaft 2a of the electric motor is a drum 6 which embraces part of the drive motor 2. Arranged centrally on the drum 6

peripherally therearound is a radially extending brake disk 6a.

Located beneath the drive motor 2 is a brake-motor 7, the output shaft 7a of which carries a shaft sleeve 7b having a part provided with a left-hand screw thread and a part provided with a right-hand screw thread. Each of these sleeve parts is in self-sustaining engagement with a respective brake shoe 8 and 9 arranged to engage the brake disk 6a on the drum 6 upon rotation of the brake-motor in a first direction.

As will be seen from Figure 3, also arranged on the brake-motor shaft 7a is an eccentric abutment or hammer means 7c which when the shaft 7a is rotated in the reverse direction, to release the brake shoes 8, 9, travels through a dead space corresponding to approximately one half of a revolution and then exerts an impact force against an element 7b' mounted on the shaft sleeve 7b.

Figures 4 and 5 illustrate an electrical hand prosthesis 10 having a rigid three-point grip. The gear belt 5 on the output shaft 4c of the gearbox 4 extends over a gear wheel or sprocket wheel 11 associated with the movable finger 13 of the prosthesis. This arrangement enables the finger 13 to be moved into engagement with a movably connected thumb 14 via a link 15.

Upon completion of the movement of the finger 13 towards the thumb 14 - which takes place subsequent to activating the drive motor 2 - the brake-motor 7 is activated causing the brake shoes 8, 9 to move rapidly towards one another and engage the brake disk 6a on the drum 6, thereby accurately locking the finger 13 and the thumb 14 in their adopted positions in the absence of any play.

Both the brake-motor 7 and the drive motor 2 are then immediately deactivated, the locking engagement being maintained through the self-sustaining effect

provided by the screw engagement between the brake shoes 8 and 9, respectively, and the corresponding screw-threaded part of the shaft sleeve 7b.

When wishing to release the finger grip, the
5 brake-motor is activated for movement in the opposite direction - which can be effected with the use of myo-impulses - whereupon the eccentric hammer element 7a illustrated in Figure 3 exerts the aforesaid impact force on the sleeve part 7b'.

10 Subsequent to releasing the brake shoes 8, 9 from the brake disk 6a the drive motor 2 is activated in the opposite direction, to reverse the movement of the finger 13 and the thumb 14.

As will be seen from the block diagram illustrated
15 in Figure 6 the control means includes a sequence part comprising four derivation units for detecting the initial and final stages of a gripping movement.

The diagram shown in Figure 7 illustrates these
20 four signals under B. The function of these signals is to release and to apply the brake at the correct moment in time. As a rule the brake shall be opened prior to the drive motor 2 obtaining a movement signal when the movable component is activated and the brake shall be applied when a negative derivative of the myo-signal is detected.
25 The current supply to the brake-motor constitutes an amplification of the time derivative of the myo-signal.

As will be seen from the block diagram in Figure
6, the drive motor 2 incorporates delay circuits which
30 are effective to prevent movement before the brake has been deactivated and to prevent play before the brake has been activated.

When wishing to grip an object with the aid of the prosthesis the patient stretches (contracts) the muscle on the upper or lower side of either arm.

35 This muscle contraction gives rise to a myo-signal, which activates the drive motor. When the patient senses

that the prosthesis grips around the object (i.e. the power is built-up), he relaxes the aforesaid muscle causing a short pulse to be sent to the brake motor. Thus, the current applied to the brake-motor constitutes
5 an amplification of the time derivative of the myo-signal. The brake shoes engage the brake disk so that the grip achieved by the prosthesis is free from play. The current to the drive motor is not interrupted until the short current pulse to the brake-motor terminates.

10 The control electronics incorporates a final stage for the drive motor and a final stage for the brake-motor. The final stage of the drive motor is suitably supplemented with a so-called battery saving circuit, which prevents unnecessary current consumption upon
15 contraction of a muscle. The battery saving circuit thus ensures that the drive motor is never activated in excess of a pre-determined time period, for example 1.5 seconds.

The various active components of the circuits, including associated capacitors, are suitably miniaturised in practice, and preferably even more discrete.
20 This type of circuit is normally designated a hybrid circuit.

For the sake of completeness it should be mentioned that the current applied to the drive motor is an
25 amplification of the myo-signal with a given time delay.

A myo-signal always corresponds to a muscle contraction, this contraction generating a positive or a negative myo-signal, depending upon whether said contraction involves a muscle on the upper or the lower
30 side of the arm, which in turn delivers current for driving the motor in one or the other direction.

As an alternative to the embodiment described above the brake disk can be provided with a number of holes (not shown) and instead of using brake shoes engaging
35 the disk a pin member (not shown) can be brought to enter one of the holes to accomplish braking. Said pin

member is then operated by the brake-motor via suitable means such as screw threads.

Industrial application

- 5 The aforescribed drive assembly or unit provided with a brake-motor can be applied in many other connections, for example, with various types of manipulator, such as industrial robots and like devices. The principle utilised to activate and de-activate the two motors is therewith
- 10 substantially the same, even though the actual guide signals can be produced in different ways, depending upon the environment or circumstances.
-

Claims

1. A method of operating and locking components of electrically operated prostheses, manipulators and the like, for example, the gripping means of an artificial arm or a robot, in which there is used a drive motor
5 from which movement is transmitted to said component via transmitting means for the purpose of effecting movement of said member, c h a r a c t e r i z e d by further using a brake-motor which is activated during the final stage of the movement for locking the component in the
10 position to which it is moved, or subsequent to completing said movement.
2. A method according to Claim 1, c h a r a c t e r i z e d by activating the brake-motor when the strength of the current applied to the drive motor exceeds a pre-
15 determined value.
3. A method according to Claim 1 or 2 for operating prostheses in which myo-signals are used to control movement of the drive motor, c h a r a c t e r i z e d by also utilising myo-signals to control the brake-motor.
- 20 4. A drive assembly for electrically operated prostheses, manipulators and the like, for example, the gripping elements of an artificial arm or robot, said drive assembly comprising
an electrically driven motor (2) having an output
25 shaft (2a),
a transmission means (4) for transmitting movement of the output shaft (2a) to a drive shaft of an active component, for example a gripping means (13)
c h a c r a c t e r i z e d by an electrically
30 operated brake-motor (7) having an output shaft (7a) which co-acts with brake means (8, 9) adapted to lock the active component (13) in an adopted position by engagement with a member (6a) operatively connected to the output shaft (2a) of the drive motor; and by control

means adapted to activate the brake-motor in the final stage of movement of said active component or upon completion of said movement.

5. A drive assembly according to Claim 4, c h a r a c-
5 t e r i z e d in that the output shaft (7a) of the brake-
motor has arranged thereon a sleeve (7b) having a first
part provided with a right-hand screw thread in self-
sustaining engagement with one brake means such as a shoe
(e.g. 8) and a second part provided with a left-hand screw
10 thread in self-sustaining engagement with another brake
means such as a shoe (e.g. 9).

6. A drive assembly according to Claim 5, c h a r a c-
t e r i z e d in that the output shaft (7a) of the brake-
motor (7) has arranged thereon an eccentric abutment
15 element (7c) which when reversing the direction of
rotation of said shaft for releasing the brake shoes (8, 9)
is arranged to travel through dead space corresponding to
approximately one half of a revolution and to then exert
an impact force on a part (7b') associated with the shaft
20 sleeve (7b).

7. A drive assembly according to any one of Claims
4-6, c h a r a c t e r i z e d in that the output shaft
(2a) of the drive motor (2) has arranged thereon a brake
disk (6a) which is concentric to the brake drum (6)
25 and against which the brake means (8, 9) engage.

8. A drive assembly according to Claim 7, c h a r a c-
t e r i z e d in that the brake drum (6) embraces part
of the drive motor (2).

9. A drive assembly according to any one of Claims
30 4-8, c h a r a c t e r i z e d in that the control means
comprises a sequence part having two or more deriving
units for releasing and applying the brake at a desired
moment in time, and one or more delay circuits for pre-
venting movement of the drive motor before the brake has
35 been released and to prevent play from occurring prior
to the brake engaging.

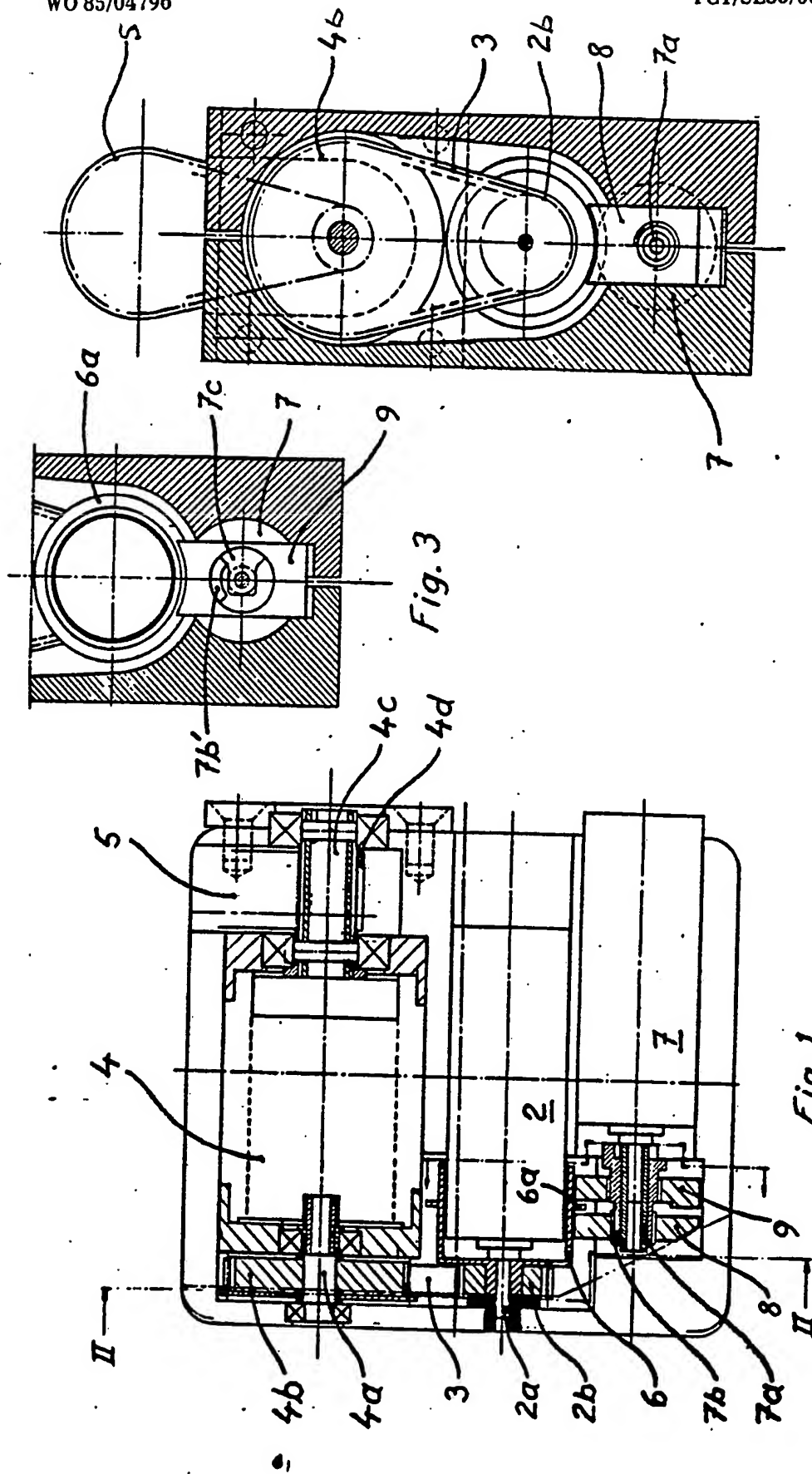


Fig. 2

Fig. 3

Fig. 1

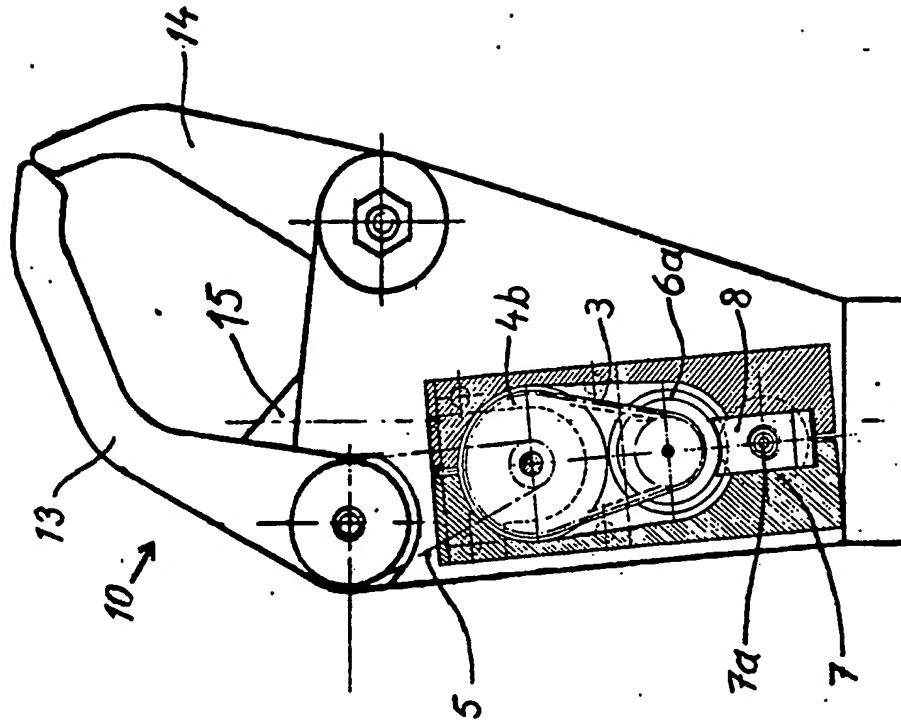


Fig. 5

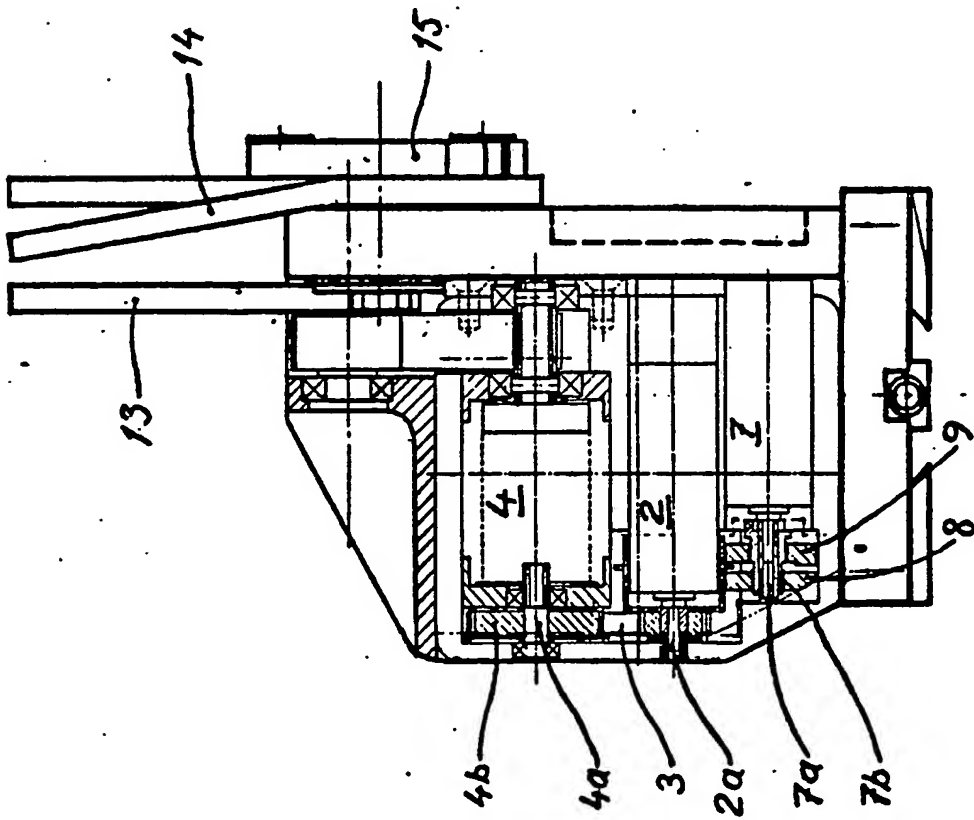


Fig. 4

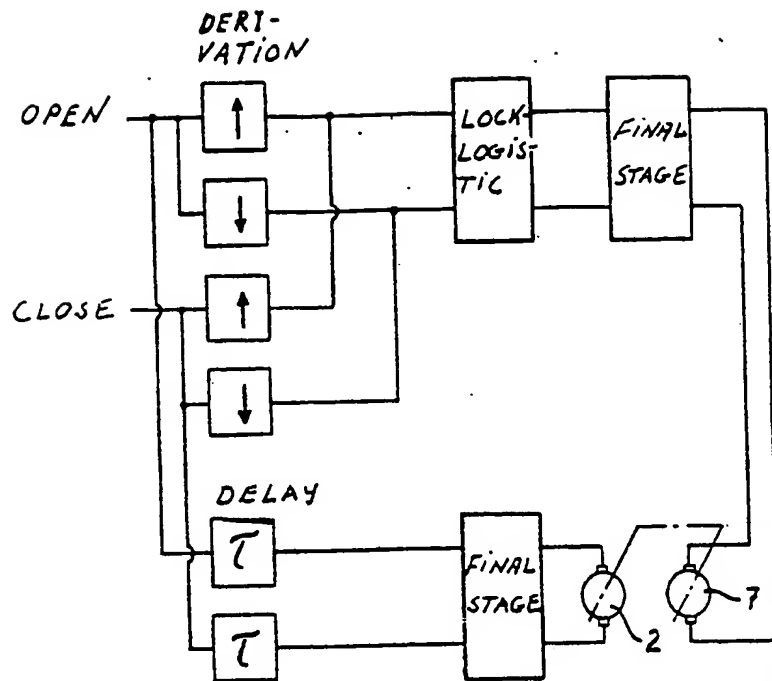


Fig. 6

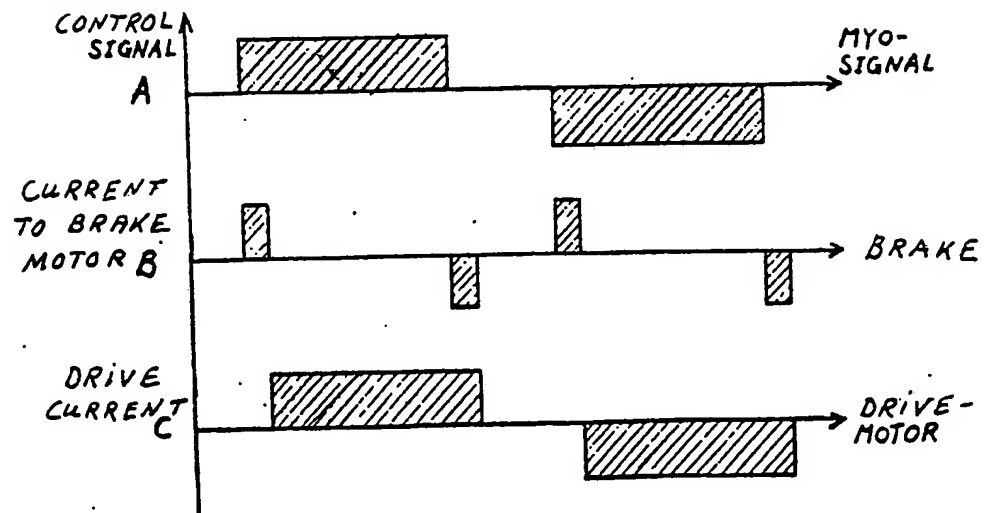


Fig. 7

INTERNATIONAL SEARCH REPORT

International Application No PCT/SE85/00182

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ⁶ According to International Patent Classification (IPC) or to both National Classification and IPC ⁴ <div style="text-align: center; font-family: monospace;">A 61 F 2/70, B 25 J 15/00</div>								
II. FIELDS SEARCHED <div style="text-align: center; font-size: small;">Minimum Documentation Searched ⁷</div> <table style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 20%; text-align: left; border-bottom: 1px solid black;">Classification System</th> <th style="text-align: left; border-bottom: 1px solid black;">Classification Symbols</th> </tr> <tr> <td style="border-right: 1px solid black; padding: 5px;">IPC 3,4</td> <td style="padding: 5px;">A 61 F 1/06, 2/54, 56, 68-72, 4/00; B 25 J 15/00, 06; F 16 D 55/22, 224</td> </tr> <tr> <td style="border-right: 1px solid black; padding: 5px;">US C1</td> <td style="padding: 5px;">3:12, 12.4, 12.5; 188:71-73, 73.3; 214:1</td> </tr> </table> <div style="text-align: center; font-size: x-small; margin-top: 5px;">Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸</div>			Classification System	Classification Symbols	IPC 3,4	A 61 F 1/06, 2/54, 56, 68-72, 4/00; B 25 J 15/00, 06; F 16 D 55/22, 224	US C1	3:12, 12.4, 12.5; 188:71-73, 73.3; 214:1
Classification System	Classification Symbols							
IPC 3,4	A 61 F 1/06, 2/54, 56, 68-72, 4/00; B 25 J 15/00, 06; F 16 D 55/22, 224							
US C1	3:12, 12.4, 12.5; 188:71-73, 73.3; 214:1							
<div style="text-align: center; font-family: monospace; font-size: large;">SE, NO, DK, FI classes as above</div>								
III. DOCUMENTS CONSIDERED TO BE RELEVANT ⁹								
Category ⁹	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³						
A	SE, B, 7407405-5 (B. LINDSTRÖM) 4 July 1977	1, 4, 7, 8						
A	DE, A, 2 426 787 (W. KARAS) 11 September 1975	1, 4, 7, 8						
A	AT, B, 338 410 (VIENNATONE GESELLSCHAFT) 25 August 1977	1, 4, 5						
<div style="display: flex; justify-content: space-between; font-size: x-small;"> <div style="width: 45%;"> <p>¹⁰ Special categories of cited documents:</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 45%;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&" document member of the same patent family</p> </div> </div>								
IV. CERTIFICATION								
Date of the Actual Completion of the International Search <div style="text-align: center; font-family: monospace;">1985-07-05</div>		Date of Mailing of this International Search Report <div style="text-align: center; font-family: monospace;">1985-07-12</div>						
International Searching Authority <div style="text-align: center; font-family: monospace;">Swedish Patent Office</div>		Signature of Authorized Officer <div style="text-align: center;"> Leif Karnsäter </div>						

L.E.

**This Page is Inserted by IFW Indexing and Scanning
Operations and is not part of the Official Record.**

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ **BLACK BORDERS**
- ☐ **IMAGE CUT OFF AT TOP, BOTTOM OR SIDES**
- ☒ **FADED TEXT OR DRAWING**
- ☐ **BLURRED OR ILLEGIBLE TEXT OR DRAWING**
- ☐ **SKEWED/SLANTED IMAGES**
- ☐ **COLOR OR BLACK AND WHITE PHOTOGRAPHS**
- ☐ **GRAY SCALE DOCUMENTS**
- ☒ **LINES OR MARKS ON ORIGINAL DOCUMENT**
- ☐ **REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY**
- ☐ **OTHER:** _____

IMAGES ARE BEST AVAILABLE COPY.

As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.